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HISTORY OF THE FEDERAL INTERAGENCY SEDIMENTATION PROJECT

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Abstract

The history of the Federal Interagency Sedimentation Project reflects a high degree of cooperation among federal agencies involved in sedimentation studies. Since 1939, the date of the Project's inception, the team has operated under the direction of two lead agencies--the U.S. Geological Survey and U.S. Army Corps of Engineers. The supporting agencies are the Agricultural Research Service, Bureau of Reclamation, U.S. Forest Service, Bureau of Land Management, Federal Highway Administration, and the Tennessee Valley Authority. Overall direction of the Project rests with the Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data. The Project's goals focus on improving and maintaining the quality of fluvial sediment data by (1) developing sediment samplers, laboratory analyzers, and automatic gages (2) evaluating methods, (3) standardizing equipment and methods and (4) procuring, calibrating and selling equipment.

Introduction

Sediment discharge measurements in the United States began in 1838 when Captain Talcott sampled flows in the Mississippi River (Interagency Committee 1940). His work stirred considerable interest, but his report tells little about his equipment and techniques. In 1843, J. L. Riddell (Interagency Committee 1940) started another sampling program on the Mississippi. He assumed that surface samples represented sediment concentrations through the full range of depths. This assumption, which was accepted by several of Riddell's contemporaries, made it unnecessary to consider the design of sampling equipment; pails and jars were used for the next several years. In 1851, Professor Forshey questioned the validity of Riddell's assumption and

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started sampling at discrete depths. At a station near Carrolton, Louisiana, Forshey used a small, weighted keg with a check valve at each end. When the keg dropped through the flow, upward pressures from the movement opened the valves; when the keg was hoisted, downward pressures closed the valves.

Late in the 19th century, sediment-sampling activities increased rapidly as federal agencies organized civil-works programs. Engineers in charge of the programs developed their own sampling equipment. For example, in 1900 the Department of Agriculture organized sampling programs on the Brazos and Wichita Rivers in Texas. Investigators, used a cylinder with a spring-loaded door at each end. A sharp pull on an auxiliary line released the doors to trap a sample inside. In 1906, the U.S. Geological Survey expanded its sampling program to include several large rivers in the western states. Investigators used a pint milk bottle held upright by a heavy pipe suspended on a cable. Water-sediment mixtures entered through a small tube sealed in the mouth of the bottle. Inflow rates were controlled by the speed at which the sampler was lowered and raised through the flow. In 1909, the Bureau of Reclamation started a sampling program on the Colorado River. Investigators used a Tait-Binckley sampler made of three metal tubes joined by two cloth sleeves. This assembly was mounted in a frame that maintained alignment with the approaching flow. Samples were trapped by pulling on an auxiliary line that rotated the center tube to twist and seal the sleeves.

Establishing the Sedimentation Project

As sampling progressed, managers realized the accuracy of sediment data was affected by lack of standardization in equipment and techniques. In 1939, Mr. G. A. Hathaway of the Corps of Engineers and Dr. E. W. Lane of the Iowa Institute of Hydraulic Research (IIHR) proposed that a project be established to remedy the situation. This proposal was endorsed by representatives of the U.S. Geological Survey, Department of Agriculture, Bureau of Reclamation, Office of Indian Affairs, and the Tennessee Valley Authority. The project, which later became known as the Federal Interagency Sedimentation Project, was established at the IIHR in Iowa City, Iowa.

The First Phase: Developing Manual Samplers

The Sedimentation Project's history can be divided into three phases. During the first phase, which spanned the interval from 1939 to about 1950, 65 types (Interagency Committee 1940) of manual sediment samplers were identified and sorted into six categories. Then Mr. Paul Benedict of the U.S. Geological Survey organized tests to evaluate a few samplers in each category. Dr. Lane supervised studies of forces on particles suspended in flowing water and found that changes in speed or direction of flow at sampler intakes cause particles to migrate across stream-tube boundaries. This condition, which is now labeled nonisokinetic sampling, causes concentrations in samples to differ from concentrations in approaching ambient flows (Interagency Committee 1941). Equipment and techniques were then developed for sampling large rivers. Samples collected daily or even weekly were sufficient to document temporal variations in the Mississippi and Missouri Rivers; however, spatial variations such as vertical concentration gradients were more difficult to chart. Point- and depth-integrating samplers were developed to insure flows at all depths were not only sampled isokinetically but were also composited according to discharge. Other work centered on measuring sediment grain sizes. The concept of using a particle's rate-of-fall in still water as an index of its diameter was adopted and then designed into the visual-accumulation tube, which is now commonly used for analyzing particles in the sand-size range (Vanoni 1975).

The Second Phase: Developing Automatic Samplers

In 1948 the Project moved from IIHR to the St. Anthony Falls Hydraulic Laboratory, University of Minnesota, in Minneapolis, Minnesota. This move coincided with the beginning of the Project's second phase which lasted about fifteen years. Research focused on problems of sampling at remote stations established to study tributaries of large rivers. These sites were difficult to reach by car or truck and impossible to serve from electric power lines. Drainage areas were small; consequently, runoff events were difficult to measure because water and sediment discharges fluctuated rapidly. These conditions called for supplementing manual equipment with automatic pumping samplers.

Designing the automatic machines involved compromises. To keep the samplers affordable, serviceable and reasonably simple, the intensity of spatial sampling had to be greatly reduced. Instead of sampling at twenty or more verticals in a cross section, automatic samplers were designed to pump from one or perhaps two points in the flow. Instead of sampling isokinetically, intakes were set at right angles to the flow or canted downstream in order to shed floating debris such as tree limbs and weeds. To keep sediment from settling in the intake pipes, pumps were geared to run at maximum capacity. The automatic machines did have redeeming features; they operated unattended and sampled at short intervals. Hydrographic peaks lasting only fractions of an hour could be charted from samples collected every three minutes. The machines ran on automobile batteries and held 72 quart-size sample containers. Field personnel recharged the batteries and brought the samples back to a central lab for processing.

The Third Phase: Developing an Automatic Sediment Gage

The third phase of the Project's history spanned the interval from the mid-1960's to the present time. Research focused on reducing sampling- and laboratory-analysis costs and speeding data-reduction procedures. An example is provided by the nuclear-type sediment-concentration gage (Ziegler et al. 1967), which was developed with financial assistance from the Atomic Energy Commission. This instrument eliminated laboratory work by sensing sediment concentrations and then printing the results on paper tape. A submersible unit held a radioactive source, radiation detector, and electronic circuits for scaling the readings. A shore-based unit held the printer and circuits for controlling the submersible unit. Ten of the gages were field tested by federal agencies. The Project assisted by coordinating the data-collection, repairing damaged gages, and replacing the short-half-life radiation sources. The tests indicated that the gages were expensive to maintain and had poor sensitivity to low sediment concentrations. Safety regulations governing use of the radioactive sources involved complicated shipping and handling procedures. Eventually, use of the instruments in the United States was terminated; however, the radiation principle was later applied to monitoring certain rivers in China and Europe.

A hematological instrument was evaluated for measuring sizes of clay and silt grains in samples. The instrument responded to voltage pulses produced when particles passed through a microscopic-sized orifice. The instrument was very sensitive; however, it failed to speed laboratory work because interfering substances in the water had to be removed and raw data had to be reduced manually. New models, which are easier to operate, are being used in special research programs.

The Project is again striving to measure sediment concentrations automatically, but this time the nuclear gages have been replaced by a vibrational-type gage. A slender, U-shaped tube carries river water from a sampling pump and also vibrates under the influence of electric coils. As concentrations increase, the additional mass causes the tube to vibrate slower; as concentrations decrease, the tube vibrates faster. Vibration rates are converted to concentrations after interfering signals have been eliminated. Support-structure vibrations are eliminated by suspending the gage on springs. Flow-rate fluctuations are eliminated by using a constant-discharge sampling pump. Water-temperature and specific-conductance shifts cannot be eliminated; therefore, correction factors are applied in the data-reduction phase. For steady-temperatures and for suspended-sediment concentrations in the 0-700 mg/L range, measurement errors are only about ±25 mg/L. The gage has a disadvantage stemming from the sampling pump's appetite for electric power. One possible solution is to eliminate the pump and replace the U-tube with a straight tube housed inside a submersible shell. Velocity heads will then sustain flows through the tube. This instrument is being developed at the Project.

Meeting New Challenges

From 1930 to about 1950, agencies were interested mainly in physical characteristics of sediment. Mass flow rates, concentrations, and particle-size distributions were sufficient to predict deposition patterns in reservoirs, irrigation canals, and navigation channels. Starting in about 1960, interests gradually expanded to include chemical and biological aspects of sediment. This has placed additional demands on the design of sampling equipment. For example, contact with metal surfaces must be avoided when water-sediment mixtures are to be analyzed for lead, mercury, and other metals. Special samplers in which all critical parts are made of plastic have now been designed. Lightweight samplers made of autoclavable plastics have also been made for biological sampling.

In 1973, Dr. William W. Emmett (1980) of the U.S. Geological Survey made a field study of the Helley-Smith bedload sampler. In 1975 the Corps of Engineers issued a contract to design a laboratory-based bedload calibration facility at the St. Anthony Falls Hydraulic Laboratory; a year later, the U. S. Geological Survey funded construction. In 1979 when the facility was finished, the Project started a sampler-testing program under direction of D. W. Hubbell (1987). The group tested two bedload samplers popular with European and Canadian hydrologists; however, most of the work was on modified forms of the Helley-Smith sampler. The data-collection phase is now complete, but issues surrounding the selection of a standard nozzle for the Helley-Smith sampler have not yet been resolved.

Standardization is still a high-priority item on the Project's goals. When the Project was young, review of standards was performed by federal agencies. Now, however, this process includes ASTM. Standards on sampling, mechanical analysis, and terminology have been adopted and documented by ASTM: Guide for Sampling Fluvial Sediment in Motion; Guide for Core Sampling Submerged, Unconsolidated Sediments; Practice for Determining Suspended-Sediment Concentrations in Water Samples; Guide for Determining Particle-Size Distributions by Manual Methods and; Terminology for Fluvial Sediment Terms.

Current Operations

The U. S. Geological Survey and U. S. Army Corps of Engineers continue to be the lead agencies for the Project. The Agricultural Research Service, Bureau of Reclamation, U. S. Forest Service, Federal Highway Administration, Bureau of Land Management, and the Tennessee Valley Authority contribute funds and guide the Project's work. Overall direction rests with the Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data. The Corps of Engineers manages equipment-supply activities by supervising and awarding manufacturing bids. Finished items are delivered to the Project for calibration and resale to government agencies and educational institutions. The Project's current staff consists of six employees; four from the U. S. Geological Survey and two from the U. S. Army Corps of Engineers.

Appendix--References

Emmett, William W. (1980). "A field calibration of the sediment-trapping characteristics of the Helley-Smith bedload sampler." U. S. Geological Survey Professional Paper 1139, U. S. Government Printing Office, Washington, D.C.

Hubbell, D. W., Stevens, H. H. Jr., Skinner, J. V., and Beverage, J. P. (1987). "Laboratory data on coarse-sediment transport for bedload-sampler calibrations." U. S. Geological Survey Professional Paper 2299, U. S. Government Printing Office, Washington, D.C.

Interagency Committee. (1940). Field practice and equipment used in sampling suspended sediment, Rpt. No. 1, Federal Inter-departmental Committee, Hydraulic Laboratory of the Iowa Institute of Hydraulic Research, Iowa City, Iowa.

Interagency Committee. (1941). Laboratory investigations of suspended sediment samplers, Rpt. No. 5, Federal Interdepartmental Committee, Hydraulic Laboratory of the Iowa Institute of Hydraulic Research, Iowa City, Iowa.

Vanoni, Vito A., Ed. (1975). Sedimentation Engineering, ASCE Manuals and Reports on Engineering Practice-No. 54, p. 414.

Ziegler, C. A., Papadopoulos, J., and Sellers, Bach. (1967). "Radioisotope gage for monitoring suspended sediment in rivers and streams," International Journal of Applied Radiation and Isotopes, Vol. 18, Pergamon Press, 585- 593.